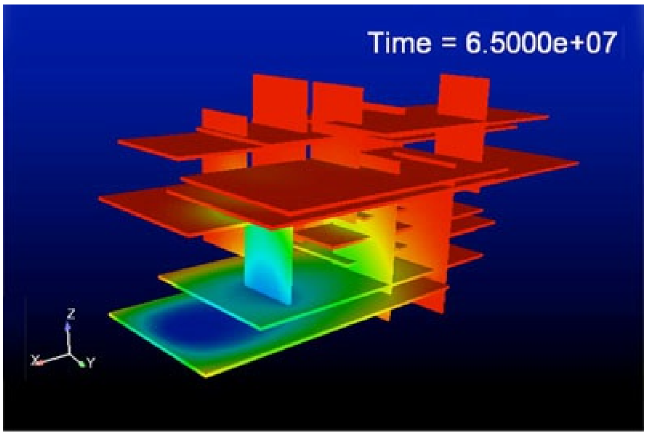
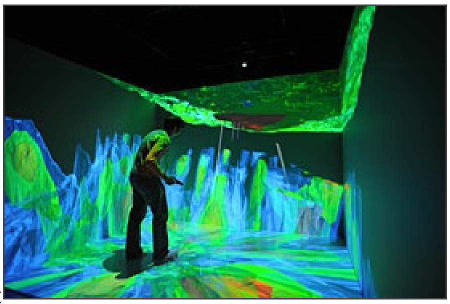


INL researchers have developed an advanced geothermal modeling application. The Fracturing And Liquid CONvection (FALCON) code enables simulation that is faster, simpler and more comprehensive. This image is from a simulation showing how FALCON can reproduce observed behavior.

Simulation capability illuminates geothermal energy potential

By Nicole Stricker, *INL Communications & Governmental Affairs*

An Idaho FALCON is offering insight into underground happenings worldwide.



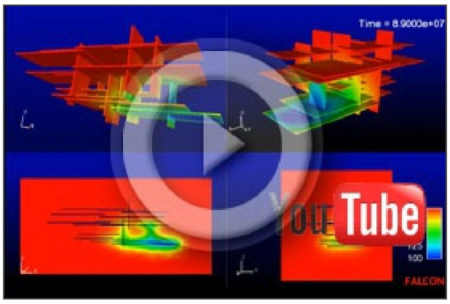
Researchers can view one of FALCON's subsurface models using the Computer Assisted Virtual Environment (CAVE) in the Center for Advanced Energy Studies (CAES) at INL.

Researchers in four countries are using an Idaho National Laboratory modeling program to simulate the subsurface physics important for geothermal energy extraction.

The Fracturing And Liquid CONvection (FALCON) code enables simulation that is faster, simpler and more comprehensive than previous options. A U.S. Department of Energy Geothermal Technologies Office award through the American Recovery and Reinvestment Act of 2009 is yielding results that will advance deployment of geothermal resources by reducing risk and costs of renewable energy development. It is helping researchers evaluate geothermal energy site data, and it may soon be able to offer predictions that could help improve geothermal energy output.

"FALCON is getting a lot of international recognition," said Robert Podgorney, who co-led its development with INL's Hai Huang. "Our collaborators need numerical models and aren't satisfied with existing tools."

Enhanced geothermal systems



FALCON enables detailed fractures and fault zones to be simulated in large scale reservoir models. Here, thermal drawdown in a geothermal reservoir is compared to numerical representations for fractured porous rock.

The project began as a quest for a simulation code that could better describe the processes underlying Enhanced Geothermal Systems (EGS). Like traditional geothermal energy, such systems tap heat within the Earth's crust to make electricity.

Harvesting that energy requires subsurface heat, water and permeable rock to converge at a single location. Such sites can be rare, making them difficult and expensive to find. Enhanced (or Engineered) Geothermal Systems require subsurface heat, but supply both fluid and rock permeability.

At EGS sites, fluid (typically water) is injected into hot rocks to stimulate pre-existing fractures. The circulation pathway returns hot fluid to the surface, where the heat is harvested to generate electricity. A 2006 Massachusetts Institute of Technology study predicted that in the next 50 years, EGS could provide more than a hundred gigawatts of cost-competitive electricity in the U.S. alone.

To maximize the performance of such systems, developers need a thorough understanding of how the heat, fluid, chemical and mechanical components interact underground. That's where FALCON comes in.

Insight from FALCON

Podgorney and Huang began developing FALCON in 2009 because the existing simulation options looked at only one physical phenomenon at a time. Trying to serially link separate modeling codes — for heat transfer and mechanics, among others — was cumbersome and susceptible to error. The FALCON code couples the mathematical models governing multiple physical systems, and solves those equations simultaneously using INL's MOOSE simulation platform.

The process has been compared to moving 1,000 train cars past a certain point. Instead of moving cars one after another across a single track, FALCON's approach is like moving all the cars

Did you know?

simultaneously across hundreds of parallel tracks.

The approach improves accuracy and incorporates the most advanced physics. Because FALCON also simplifies the computational process, simulations can be completed without the need for a supercomputer.

Geothermal research groups around the world are now using FALCON to evaluate their site data. The collaborations help improve the code by providing data sets from known geothermal sites. Such data tests FALCON's capabilities in new ways.

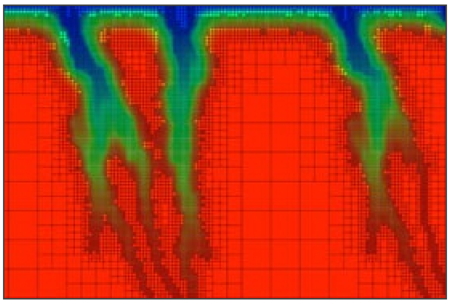
"It can be difficult to get real-world data sets for these systems," Podgorney said.

The INL simulation platform MOOSE stands for Multi-physics Object Oriented Simulation Environment. There are now more than 20 MOOSE-based applications in various stages of development. Developers are naming these applications for indigenous Idaho animals, but are not trying to devise a meaningful acronym for each new modeling code.

FALCON developers are now working with geothermal energy research teams from Australia, New Zealand, Iceland and America.

International reach

For example, Podgorney is coordinating numerical modeling for the Iceland-based GEOthermal Research Group (GEORG). New Zealand's Institute for Earth Science and Engineering at the University of Auckland has licensed FALCON and is comparing its output with other codes to evaluate system behavior. Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation(CSIRO), is using FALCON as a starting point to build its own MOOSE-based simulation capability.



FALCON is being used to model how the injection of cold water might increase the permeability, and hence the energy production,
at one geothermal site.

"They're actually launching and developing a national program on geothermal energy," Podgorney said. "They toured most of the U.S. Department of Energy national labs to look at capabilities and thought what INL had to offer with MOOSE and FALCON was far superior for both capabilities and collaborative opportunities."

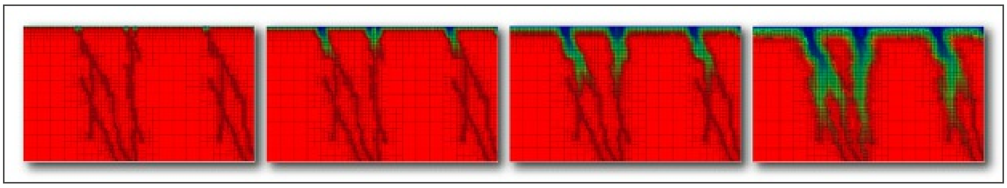
Right here at home, INL is working with University of Utah's Energy & Geoscience Institute (EGI) to model ways for improving the performance at an existing geothermal site. Podgorney's team used FALCON to model how the injection of cold water might increase the permeability of the system, and hence the geothermal energy production at the Raft River Power Plant. This experimental concept is too advanced for many other models to handle.

Fluid injection at Raft River started this month. Beyond enabling researchers to fine-tune FALCON, the outcome will reveal whether FALCON's predictions of the system behavior prove to be accurate.

"Our models gave a range of potential behaviors," Podgorney said. "If performance bears out the model, the geothermal community will be one step closer to having a tool capable of accurately predicting complex behavior at operating geothermal sites."

Learn more:
http://www1.eere.energy.gov/geothermal/egs_animation.html
http://www.youtube.com/watch?v=O6r_3AgI49Y

(Posted Sept. 12, 2013)



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